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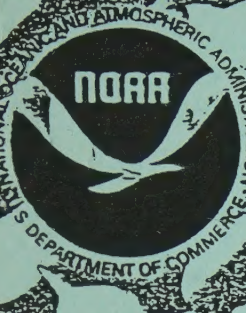

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APRIL 1990

THE USE OF SEAL BOMBS ON DOLPHIN IN THE YELLOWFIN TUNA PURSE-SEINE FISHERY

By

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Cheryl B. Glick
Robert C. Holland
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ADMINISTRATIVE REPORT LJ-90-09

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ABSTRACT

We examined Marine Mammal Set Log forms completed by National Marine Fisheries Service tuna-dolphin observers to determine whether seal-bomb use increases dolphin mortality within a set, and to detect when, during a dolphin set, seal bombs were used. We estimated that seal bombs were used in 40% of all dolphin sets. We were unable to detect a direct relationship between the use of seal bombs and increased mortality. Most seal-bomb use occurred within a dolphin set during the chase and encirclement stages.

INTRODUCTION

This report is an evaluation of whether seal bombs used in the yellowfin tuna purse-seine fishery cause increased mortality or serious injury to dolphins in the eastern tropical Pacific (ETP). The most common method of catching large yellowfin tuna in the ETP is to set on schools of dolphins that are followed by tuna (Perrin 1969). Currently, small firecracker-like explosives (a.k.a. seal bombs) (Myrick et al. 1990a) are used by some vessels in the U.S. purse-seine fleet in sets on dolphins to catch yellowfin tuna.

The fishing process can be divided into four stages: chase, encirclement, capture, and release of the dolphins. In the chase, up to six speedboats chase and herd the animals in order for the seiner to encircle the dolphin school with a purse seine. In addition, a helicopter is sometimes used to spot schools of dolphins and then actively herd them. After the net is released into the water by the seiner, the chase stage ends and the encirclement stage begins. During encirclement, dolphins are not yet completely surrounded by the net and the speedboats, helicopter, seiner, and net skiff try to prevent the dolphins from escaping through gaps in the net to evade capture. At the full pursing of the net, dolphins are captured and preparations for the backdown procedure begin. The net is retrieved to about ¼ of its length (we refer to this stage as "Net Roll"), the seiner "backs

down" by shifting into reverse, and the net is pulled out from under the dolphins effecting their release. Many U.S. tuna purse-seiners have incorporated the use of seal bombs into all of the stages of a dolphin set.

The Marine Mammal Protection Act of 1972, as amended by PL 100-711 (November 23, 1988) provides that "The Secretary [of Commerce] shall prescribe regulations, effective April 1, 1990, to prohibit or restrict the use of [seal bombs] in the course of yellowfin tuna fishing unless [it is determined that seal-bomb use] does not result in physical impairment or...[increase] mortality of marine mammals."

This report focuses on: 1) the frequency of use of seal bombs, and 2) in what stages of the set seal bombs are used most often, and 3) whether the use of seal bombs increases the mortality of dolphins.

METHODS

The responsibility of collecting data on the ETP tuna purse-seine fleet fishing operations rests with the National Marine Fisheries Service (NMFS) and the Inter-American Tropical Tuna Commission (IATTC). NMFS and IATTC observers aboard tuna seiners complete a purse-seine set log to report the details of the fishing activity during each set of a cruise. We examined NMFS cruise set logs for U.S. boats from March 15, 1989 through September 22, 1989. The bulk of the data used in this report was obtained from NMFS-observer Marine Mammal Set Logs (MMSLs). For purposes of this report we have assumed that the frequency of seal-bomb use found in IATTC-monitored cruises (U.S. and foreign boats) is similar to that in NMFS-monitored (U.S.) cruises.

Prior to March 1989, observers were not required to record seal-bomb use. After March 1989, a code block was added to the MMSL form that asked the question, "Were [seal bombs] used within 100 yards of the porpoise [dolphin] in this school at any time during the chase or set?, yes or no, blank if undetermined." NMFS maintains a large data base that contains all completed NMFS-monitored cruises. The 100-yard criterion was not established to indicate a line between injury and no injury. Set data for all cruises that used MMSL forms requiring seal-bomb-use documentation were treated with a FORTRAN program designed to select variables of interest for each set and to perform calculations on these variables. To conduct this study we assembled three data bases: Data Base I, II, and III. Data Base I and Data Base II were constructed from MMSLs containing the seal-bomb use code block. Data Base II is constructed from information gathered by manually searching the MMSL and documenting the details of seal-bomb use found in the observer's written comments. (Appendices A and B

contain descriptions of the variables used in Data Base I and Data Base II.) Data Base III consists of comments gathered in opportunistic interviews with 12 NMFS tuna/dolphin observers returning from cruises in 1989.

Dolphin mortality is the result of many factors. To determine whether seal bombs affect dolphin mortality, a log-linear model for dolphins killed was postulated and a test of the effect of seal-bombs on mortality was formulated as a multiple regression problem. We chose to formulate this problem in terms of a multiple regression (as opposed to using analysis of variance) because of the unbalanced nature of the data. The data used in this analysis consist of 1038 dolphin sets. This reflects the fishing effort of 27 skippers.

To better identify variation in the data resulting from the use of seal bombs, several other factors affecting dolphin mortality were considered. To account for variability in operator performance, a "skipper effect" was built into the model. However, as the majority of skippers were represented by only one trip in the data set, a true skipper effect was not identifiable. Instead, the modeled "skipper effect" is likely to be confounded with other possible factors, including effects of observer, vessel and crew. In addition, because common dolphins, *Delphinus delphis*, are thought to have a higher mortality rate per set than other species of dolphins (IATTC workshop 1989), a "common dolphin effect" was included in the model. A set with a capture of more than fifty percent of common dolphins was defined as a "common dolphin set".

Plots of dolphin mortality per set versus tons of tuna caught per set and dolphins captured per set (Figs 1,2) do not reveal any trends (e.g., linear or quadratic) in dolphins killed with increased dolphins captured or tons of tuna caught. Dolphins killed, averaged over different ranges of dolphin school size and tons of tuna caught, suggest a nonlinear increase in kill as a function of both the numbers of dolphins captured and tuna caught (Table 3). Based on these observations, tons of tuna caught and the size of the dolphin school that was captured were not modeled as covariates but instead were considered to affect dolphin kill differently over various ranges. To remove these sources of variation, a tuna effect and a capture effect were included in the model.

Lastly, a "seal-bomb effect" was included in the model. The test of interest in this analysis was against the null hypothesis that there is no seal-bomb effect on dolphin mortality (i.e., $\xi=0$, see below).

The resulting model was:

$$\ln(kill+1)_K = \alpha_0+\alpha_i X_i+\beta X_{27}+\gamma X_{28}+\delta_1 X_{29}+\delta_2 X_{30}+\xi X_{31}+\epsilon_K , \quad (1)$$

i=1,...,26 and K=1,...,1038

where

α_0 = Constant term

α_i = "Skipper-effect", i=1,...,26; X_i=1 if the set was made by skipper i; X_i = 0 otherwise

β = Common dolphin effect, X_{27} = 1 if the set was classified as a common dolphin set; X_{27} = 0 otherwise

γ = Capture effect, X_{28} = 1 if capture was greater than 600 animals; X_{28} = 0 otherwise

δ_j = Tuna effect, j = 1,2; if number of tons caught was less than or equal to 15 then X_{29} = -1, X_{30} = 1; if number of tons caught was greater than 15 but less than or equal to 40, X_{29} = 0, X_{30} = -2; if number of tons caught was greater than 40, X_{29} = 1, X_{30} = 1

ξ = Seal-bomb effect, X_{31} = 1 if seal-bomb use was positive for the set; X_{31} = 0 otherwise

ϵ = Error term for the K^{th} observation; errors are assumed to be independent and identically distributed $N(0,\sigma^2)$

The above can be expressed in matrix notation as Y = XB + E, for which an estimate of the vector of parameters B can be obtained by least squares (Draper & Smith 1981). The natural logarithm transformation was chosen to stabilize the variance, and to make the data more nearly normal. The addition of 1 (i.e., "kill+1") ensures that the logarithm function is defined for sets with zero kill. Plots of ln(kill+1) versus tons of tuna caught and dolphin school capture size are shown in Figure 3.

Residuals obtained from a linear regression analysis of the log-transformed kill data showed increasing negative values with increased predicted kill. This skewed behavior is probably the result of this analysis attempting to accommodate several extreme kill values and the large number of sets with no dolphin kill occurring over a broad range of tuna catches and sizes of dolphin schools captured (Figs 1,2). To evaluate the degree to which this lack of fit may impair detection of an effect of seal bombs on dolphin mortality, an additional analysis of the data set was performed whereby the data were separated into kill and zero-kill sets. Sets with kill greater than zero were reanalyzed as a multiple regression problem. The log-linear model (Equation 1) was modified slightly to better describe the reduced data set (Table 4). Two different strata (ranges) of capture, capture less than or

equal to 1000 dolphins and greater than 1000 dolphins, and only two strata of tuna, less than or equal to 30 tons and greater than 30 tons, were used ($\delta_1 X_{29}$, $\delta_2 X_{30}$ were replaced by δX where X = 1 if tons were greater than 30; X = 0 otherwise).

For zero-kill sets, a test of an effect of seal bombs on dolphin mortality was based on the comparison of the percentage of sets, with and without seal-bomb use, for each skipper. Only fifteen skippers were represented by data adequate for a paired analysis. For each skipper, the percent zero-kill sets with seal-bomb and no seal-bomb use were estimated as the number of sets with zero kill in which seal bombs were (or were not) used, divided by the total number of sets. Each percentage was then divided by the median tons of tuna caught to account for the effect of the tuna catch on dolphin kill.

RESULTS

Data Base I. March 15, 1989 - September 22, 1989

Seal-bomb use was noted in 418 (40.2%) of 1039 dolphin sets for which seal-bomb use or non-use was reported (Table 1). In this comparison we excluded 365 sets in which the observer could not determine whether seal-bombs were or were not used.

The average number of dolphins killed per set when seal bombs were used was only slightly higher than the average kill per set when seal bombs were not used (Table 2). Analysis showed however, that this difference was not significant. (Additional data on Data Base I are found in Tables 9 - 11.)

The log-linear model proposed to describe dolphin mortality explained some of the variation observed in the data ($p < 0.0005$ ($F = 18.55$, with 31 and 1006 d.f.), $R^2 = 0.36$). The seal-bomb effect was not significantly different from zero ($\xi = 0.0078$, $s_\xi = 0.08417$, $p = 0.926$). A normal probability plot of the residuals had a downward bowlike appearance indicating the distribution of the residuals was skewed to the left. Plots of residuals from this regression analysis showed that the logarithm transformation largely stabilized the variance.

Results of the separate analyses of sets with kill and zero-kill were similar to those obtained in the initial analysis. No significant effect of seal bombs on dolphin mortality was found ($\xi = -0.1239$, $s_\xi = 0.1401$, $p = 0.382$) for the analysis of sets with kill greater than zero. Again, the log-linear model explained some of the variation in the data ($p < 0.0005$ ($F = 8.10$, with 30 and 451 d.f.), $R^2 = 0.35$). A normal probability plot of the residuals showed that the distribution was still slightly left skewed. We did not detect a significant difference between the weighted percentage of zero-kill sets with and without seal-bomb use (Wilcoxon signed rank test, $p = 0.2115$).

Frequency of seal-bomb use listed by skipper (Table 5) revealed that 43% of the skippers used seal bombs in more than 50% of their dolphin sets. In addition, 29% of the skippers did not use seal bombs at all and 39% used them in less than 15% of their sets on dolphins.

Listed by vessel (Table 6), the data on seal-bomb use show that on more than 44% of the vessels, seal bombs were used in more than 50% of the dolphin sets. This comparison also showed that on 30% of the vessels, seal bombs were not used at all and on 37% they were used in less than 15% of the dolphin sets.

Data Base II. Sets with Seal-Bomb Use

Of the 418 dolphin sets represented in Data Base I in which seal bombs were used, 277 are documented by MMSLs containing written comments detailing in what stage and from what platform they were used. In 152 dolphin sets, seal bombs were used during the chase or encirclement stages only (Table 8). Fifty-nine dolphin sets had seal-bomb use only during net roll or backdown. Seal bombs were used in only one stage in 204 sets, in two stages in 36 sets, and in three stages in 3 sets.

On one cruise (Cruise 1257) seal bombs may have been used in multiple stages of each set. However, observer comments for this cruise do not provide enough information to identify multiple use. If two-stage use occurred in all sets of this cruise, then 75 (not 36) sets involved two-stage use of seal bombs.

An earlier record (NMFS observer 1987), located in a preliminary search indicated possible direct mortality from a seal bomb explosion. Nevertheless, no support for apparent direct injury or mortality by seal bombs was found in comments in MMSLs from Data Base II.

Data Base III. Observer Interviews

Based on an observers identification of seal bomb types (i.e., manufacturer) during post-cruise interviews, at least three types of seal bombs were used (Table 10). On 6 of 12 cruises, Panamanian-made seal bombs were used, on four cruises Class-C (U.S.) seal bombs were used, and on one cruise Mexican-made seal bombs were used. On one cruise, Class-C seal bombs were used in clusters. These and other types of seal bombs have been described by Myrick et al. (1990b).

Frequency of use reportedly ranged from 2 seal bombs per set, to 600 seal bombs per set. In most cases, seal-bomb use was between 10 and 50 per set.

DISCUSSION

Dolphin Mortality

There are numerous causes for mortality during a set on dolphins made by purse seiners. It is difficult to isolate obvious effects of seal bombs on dolphin mortality when direct injury is not apparent. We failed to find any reports of direct injury from seal-bomb use during a dolphin set with one possible exception in 1987. Furthermore, we were unable to detect a significant effect of seal bomb use on dolphin mortality.

Although a log-linear model for numbers of dolphins killed was selected to test for an affect of seal bombs on dolphin mortality, it is worth noting that similar results were obtained based on a linear model using a weighted least squares procedure and a regression on the transformed variable, square root (kill). Inspection of residual plots showed that the performance of the logarithm transformation was better than that of the other two methods. However, none of the procedures investigated completely stabilized the variance. Tendency towards negative residuals persisted even when kill sets were analyzed separately, although the severity was considerably reduced. Even with zero-kill sets excluded from the data set, sets involving low dolphin mortality made up the majority of the data base. Infrequent sets with high dolphin mortality probably exerted considerable influence on the least squares fit.

If seal bombs influence dolphin mortality, it may be that with the present data set, the effect is too small to be statistically significant. In addition, the inability of this analysis to detect an affect of seal bombs on dolphin mortality may be a result of the model we used. More data would permit greater modeling flexibility (e.g., further stratification of dolphin capture and tons of tuna caught) and probably reduce the unbalanced nature of the design. Moreover, our model considers only use or non-use of seal bombs and does not stratify a seal-bomb event by the stage of the set in which the event occurred or the distance between the exploding seal bomb and the nearest dolphin. The grouping of disparate cases may have weakened the ability of this analysis to detect a seal-bomb effect. Additional data and further stratification of seal-bomb use would help resolve this point.

Seal-Bomb Use

Frequency of seal-bomb use within 100 yards in sets made on dolphins between March 15 and September 22, 1989 was at least 40 percent. It has been suggested that this estimated rate of usage is an underestimate (DeMaster 1989). This was suggested because a large portion of seal-bomb use goes unrecorded because the code on the MMSL pertaining to seal-bomb use requires that the observer witness the use of seal bombs within 100 yards of a dolphin. When seal bombs are thrown during the chase by the helicopter and speedboats, those platforms are usually miles from the observer and details of their activities are not discernible (pers. comm. NMFS observers). In addition, many sets in which seal bombs are used are commonly aborted before encirclement. Seal-bomb use in such aborted sets have been excluded in our study.

It was difficult to gain a historical perspective concerning the earliest use of seal bombs in dolphin sets because of a lack of documentation. The earliest date recalled by former NMFS observers was 1980 (A. Jackson, NMFS pers. comm. 1989).

In most cases seal bombs are used to alter the behavior of the dolphins. This behavior modification can be divided into at least two obvious categories: 1) use of seal bombs to herd and capture dolphins in the purse seine, and 2) use of seal bombs to drive dolphins out of the net. There are two other categories that are poorly documented but have been expressed in personal communications. They are 3) use of seal bombs to cut out sections of a dolphin school that are not carrying fish, and 4) use of seal bombs to start a dolphin school running. The purpose of this last procedure is to make visible any fish that might not be seen otherwise under a dolphin school.

Frequency of Seal-Bomb Use

The number of seal bombs used per set was poorly recorded in the observers written comments. Interviews have revealed that an estimated maximum of six hundred bombs were used in a single dolphin set. Several observers reported an average of two hundred bombs in every set, for all sets. There were also cases in which only a few bombs were used per set. Forty-three percent of the skippers that made the cruises that are contained within Data Base I used seal bombs in more than fifty percent of their dolphin sets. Nevertheless, we suspect that the reported number of bombs used per set may be low because of the constraints of the current method used to record seal-bomb use and the observational limitations of the observers.

Stages of Set

Seal-bomb use occurred in all stages of a dolphin set. Seal bombs were thrown from most available platforms during each stage of a set. For the most part, our data indicate that when seal bombs were used, use occurred seventy-five percent of the time in chase and encirclement and twenty-five percent of the time during backdown. Seal bombs were used in multiple stages of a dolphin set twenty-percent of the time.

Types of Seal Bombs

Eight of the twelve observers interviewed identified foreign seal bombs as the explosive used solely by their vessels. Six of these observers identified the type used as a Panamanian seal bomb. Panamanian seal bombs have been shown to be much more powerful than U.S. Class C explosives (Myrick et al. 1990a&b). Documented use of Class-C clusters has also been reported (Table 8).

CONCLUSIONS

Currently, seal bombs are probably being used in 40-percent or more of all sets made on dolphins in the U.S. tuna purse-seine fishery monitored by NMFS observers. Use of the more powerful Panamanian bombs by U.S. vessels was common, but it was not possible to estimate how often they were used.

Although there may be a relationship between the number of dolphins killed per set and the use of seal bombs, we were unable to detect it in our study. The current method of reporting seal-bomb use in tuna purse-seine fisheries makes it extremely difficult to isolate the effects seal bombs have on the relationships between variables in a dolphin set. A more detailed data sheet on the use of seal bombs during a set on dolphins to quantify their effects would improve precision in determining these relationships.

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Table 1. Percent of dolphin sets made between March 15, 1989 - September 22, 1989 that show seal-bomb use*

Sets with Seal Bombs	418	40.2%
Sets without Seal Bombs	621	59.8%
	1039††	

* Excluding undetermined sets

††1038 sets from Data Base I were used in our analysis because one skipper made only one set on dolphins and was excluded.

Table 2. Relationships between variables for dolphin sets made between March 15, 1989 - September 22, 1989 with and without seal bombs

	With Seal Bombs	Without Seal Bombs
Number of sets sampled	418	621
Average dolphin kill/set	5.13	5.10
Average dolphin injury/set	0.19	0.25
Average tons tuna caught/set	20.92	21.79
Dolphin kill/ton of tuna caught	0.18	0.23
Dolphins killed/set	1123	941
Dolphin captured/set	737	668

Table 3. Average dolphin mortality and standard deviations for various ranges of size of dolphin school captured and tons of tuna caught

Capture size	Number of sets	Average mortality	Standard deviation
≤ 200	240	1.02	3.656
201 - 400	216	1.32	3.624
401 - 600	155	1.47	3.448
601 - 800	140	3.39	11.253
801 - 1000	92	4.72	10.299
1001 - 1200	53	11.15	29.247
1201 - 1400	22	8.18	19.682
1401 - 1600	27	11.96	22.011
1601 - 1800	23	43.61	166.623
1801 - 2000	24	12.71	20.641
> 2000	46	26.91	68.205
Tons of tuna caught			
≤ 2	112	1.18	4.138
3 - 5	126	1.18	4.286
6 - 10	168	2.18	8.727
11 - 15	140	1.60	3.883
16 - 20	97	4.13	12.567
21 - 30	169	3.47	7.536
31 - 40	96	5.25	12.983
41 - 50	44	14.34	33.889
51 - 60	31	5.65	10.151
61 - 80	30	41.03	145.957
81 - 100	16	49.00	111.769
> 100	9	13.78	15.123

Table 4. Average dolphin mortality and standard deviations for various ranges of size of dolphin school captured and tons of tuna caught (zero-kill sets excluded)

Capture size	Number of sets	Average mortality	Standard deviation
≤ 200	52	4.71	6.702
201 - 400	74	3.87	5.359
401 - 600	67	3.40	4.589
601 - 800	75	6.32	14.801
801 - 1000	62	7.00	11.916
1001 - 1200	38	15.55	33.643
1201 - 1400	13	13.85	24.351
1401 - 1600	21	15.38	23.972
1601 - 1800	19	52.79	182.814
1801 - 2000	21	14.52	21.500
> 2000	40	30.95	72.384
Tons of tuna caught			
≤ 2	28	4.71	7.287
3 - 5	44	3.36	6.772
6 - 10	65	5.65	13.375
11 - 15	51	4.39	5.422
16 - 20	54	7.43	16.160
21 - 30	96	6.10	9.174
31 - 40	48	10.50	16.864
41 - 50	26	24.27	41.530
51 - 60	24	7.29	11.039
61 - 80	25	49.24	159.125
81 - 100	13	60.31	121.970
> 100	8	15.50	15.194

TABLE 5. Percent of dolphin sets made between March 15, 1989 - September 22, 1989 with and without seal-bomb (SB) use, listed by skipper

Skipper	Number of dolphin sets	Percent	
		With SB	Without SB
A	23	8.7	91.3
B	27	18.5	81.5
C	13	100.0	0.0
D	32	0.0	100.0
E	31	3.2	96.8
F	17	82.4	17.6
G	105	95.2	4.8
H	19	84.2	15.8
I	40	50.0	50.0
J	59	23.7	76.3
K	33	0.0	100.0
L	23	65.2	34.8
M	26	34.6	65.4
N	45	75.6	24.4
O	30	0.0	100.0
P	1	0.0	100.0
Q	16	100.0	0.0
R	51	25.5	74.5
S	40	0.0	100.0
T	75	32.0	68.0
U	49	0.0	100.0
V	51	0.0	100.0
W	22	77.3	22.7
X	44	88.6	11.4
Y	56	71.4	28.6
Z	40	10.0	90.0
AA	23	95.7	4.3
BB	48	0.0	100.0

Table 6. Percent of dolphin sets made between March 15, 1989 - September 22, 1989 with and without seal-bomb (SB) use, listed by vessel

Vessel	Number of dolphin sets	Percent	
		With SB	Without SB
A	45	75.6	24.4
B	49	0.0	100.0
C	56	71.4	28.6
D	75	32.0	68.0
E	23	8.7	91.3
F	1	0.0	100.0
G	51	0.0	100.0
H	35	91.4	8.6
I	16	100.0	0.0
J	17	82.3	17.6
K	78	0.0	100.0
L	26	34.6	65.4
M	31	3.3	96.7
N	13	100.0	0.0
O	40	0.0	100.0
P	21	0.0	100.0
Q	46	19.6	80.4
R	51	25.5	74.5
S	42	90.5	9.5
T	70	97.2	2.8
U	44	88.6	11.4
V	32	0.0	100.0
W	40	50.0	50.0
X	22	77.3	22.7
Y	59	23.7	76.3
Z	23	65.2	34.8
AA	33	0.0	100.0

Table 7. Platforms and stages associated with seal-bomb use in 277 dolphin sets made March 15, 1989 - September 22, 1989, according to observer written comments in MMSLs

Platform	Variable* Abbreviation	Number of sets	Percent
Chase$	SBUSEDCHAS	75(114)	31.5(41.2)
Helicopter$	SBHELOCHAS	23(62)	10.3(22.4)
Seiner	SBSEINCHS	8	2.9
Speedboat	SBSPDCHSE	30	10.0
Net skiff	SBSKIFCHSE	1	0.5
Encirclement$	LETGORNGUP	120(159)	50.4(57.4)
Helicopter$	SBHELOENCR	38(77)	16.0(27.8)
Seiner	SBSEINENCR	82	29.6
Speedboat	SBSPDENCR	33	11.9
Net skiff	SBSKIFENCR	11	4.0
Seiner (at tow line)	SBSEINTOW	27	9.7
Seiner (at bow)	SBSEINBOW	39	9.8
SpeedBoat (tow line)	SBSPDTOW	18	6.5
Helicopter (tow line)	SBHELOTOW	13	4.7
Net Roll (unspecified platform)	RNGUPBKDST	3	1.1
Backdown	BKDSTBKDFN	86	31.4
Seiner	SBSEINBKD	72	26.0
SpeedBoat	SBSPDAPEX	2	0.7

* For full descriptions of variables see Appendix C, Section 1

$ Seal-bomb use in cruise 1257 by ships' helicopter occurs in chase and or encirclement. Observer did not indicate more specific information. Numbers outside parenthesis do not include cruise 1257, while the numbers inside assume use in both stages of sets by ships' helicopter for cruise 1257.

Table 8. Results from post-cruise interviews with NMFS observers concerning seal-bomb type and number used per set made between March 15, 1989 - September 22, 1989

Observer	Type of bombs used	Number/set
A	Panamanian	2 - 5
B	Class C	200(600 high)
C	Red Mexican	20
D	Class C	200*
E	Panamanian	100
F	Panamanian	12
G	Panamanian	8 -10
H	Class C	10
I	Class C	50
J	Panamanian	20
K	Unknown Foreign	25 - 50
L	Panamanian	15

*used singly and in clusters

Table 9. Data for sampled sets made between March 15, 1989 - September 22, 1989

Number of sets	1404
Dolphins killed	6,496
Dolphins injured	297
Tuna caught (tons)	23,653
Dolphins chased	1,420,467
Dolphins captured	920,115

Table 10. Relationships between variables for sampled sets made between March 15, 1989 - September 22, 1989

Number of sets	1404
Dolphin kill/set	4.63
Dolphin injury/set	0.21
Tons of tuna caught/set	16.8
Dolphin kill/ton of tuna caught	0.21
Average dolphins chased/set	1011
Average dolphins caught/set	655

Table 11. Data for sampled sets made between March 15, 1989 - September 22, 1989 with and without seal bombs

	With seal bombs	Without seal bombs
Number of sets	418	621
Dolphins killed	2143	3164
Sets with zero kill (%)	51.0	55.4
Dolphins injured	122	152
Tuna caught (tons)	8,743	13,532
Dolphins chased	469,483	584,605
Dolphins captured	308,069	414,561

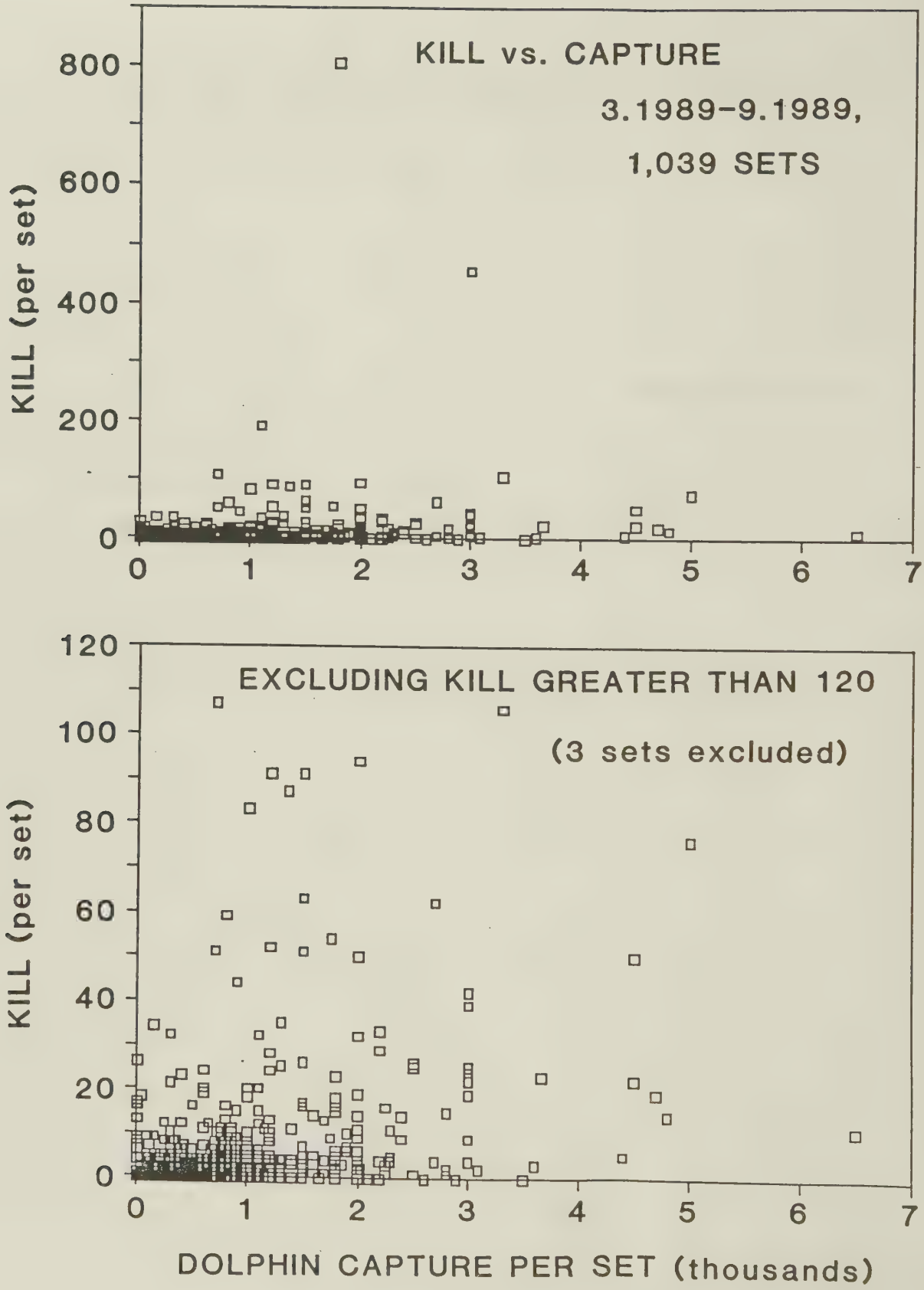


Figure 1. Plots of dolphin kill per set vs. dolphin capture per set

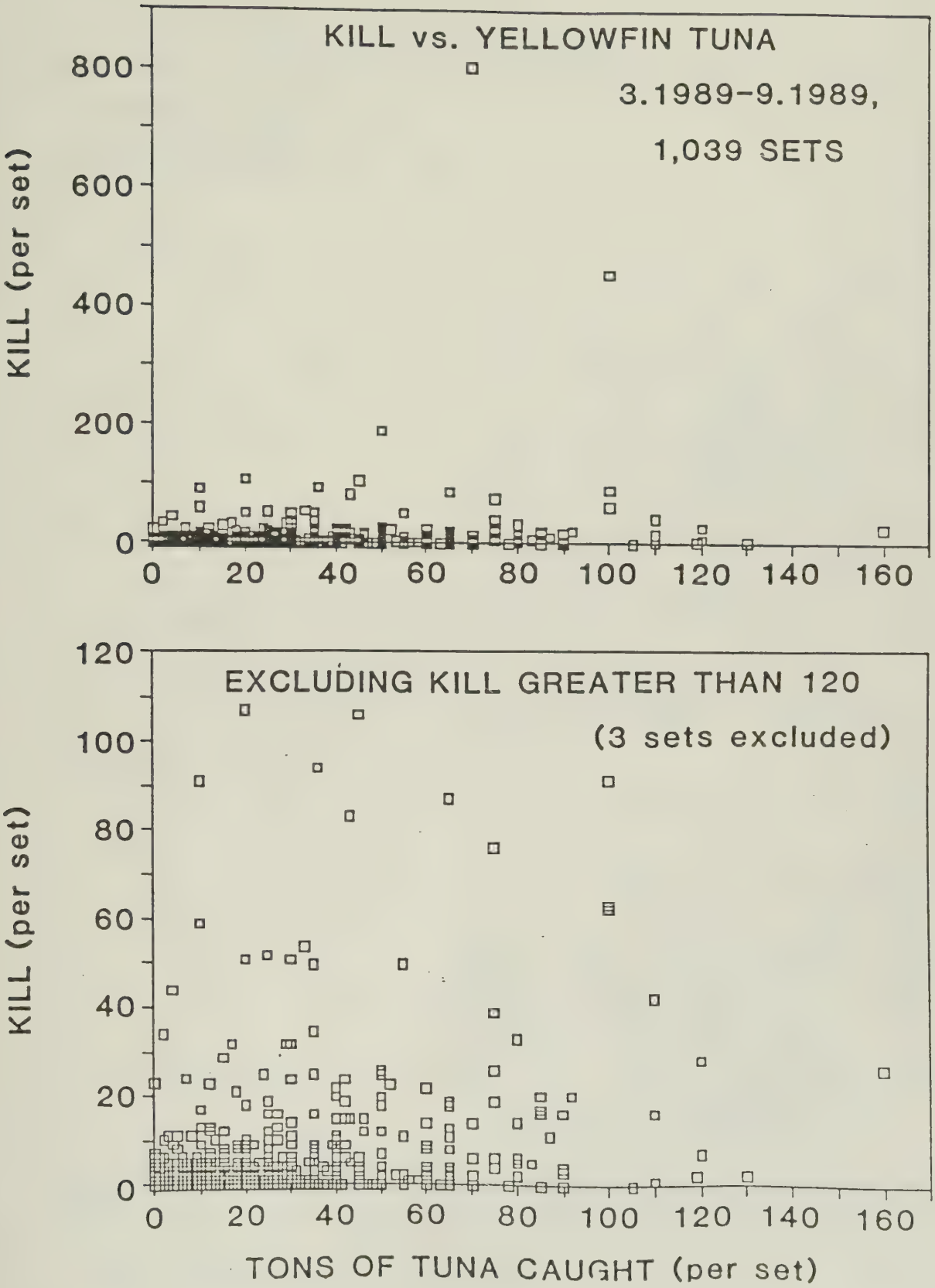
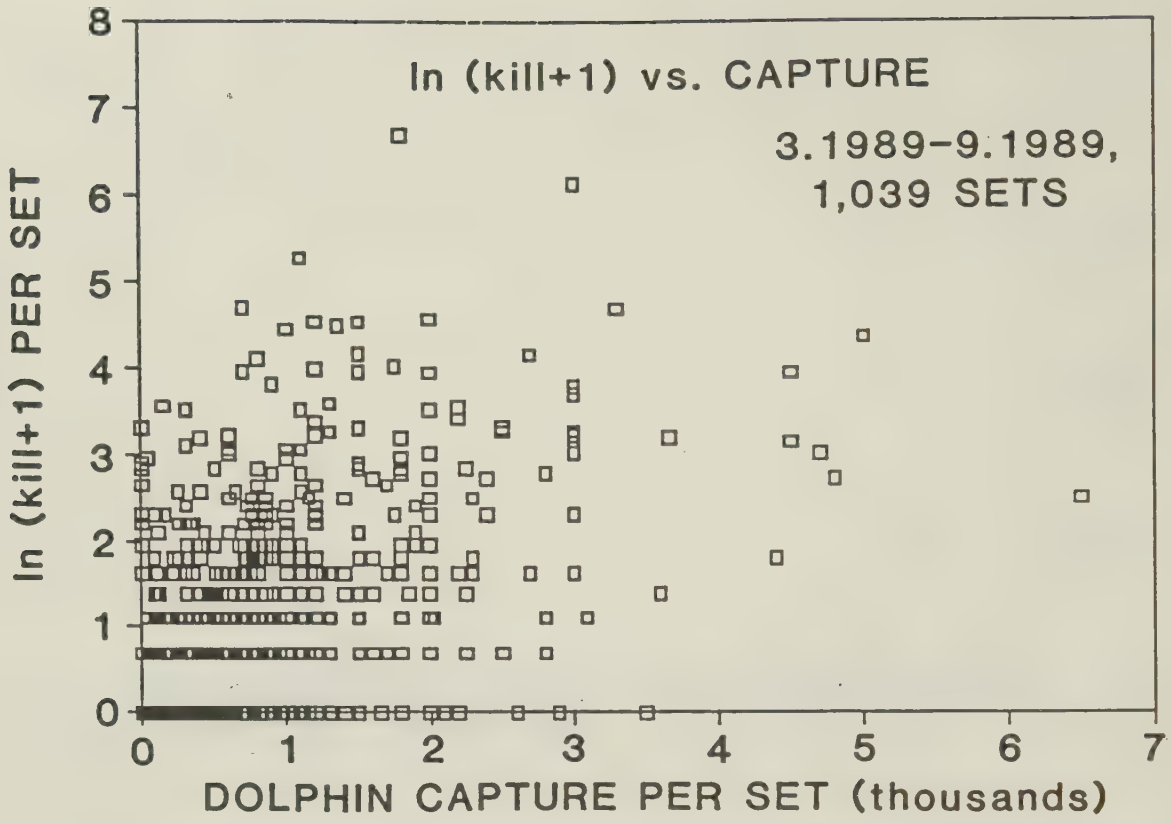


Figure 2. Plots of dolphin kill per set vs. tons of tuna caught per set



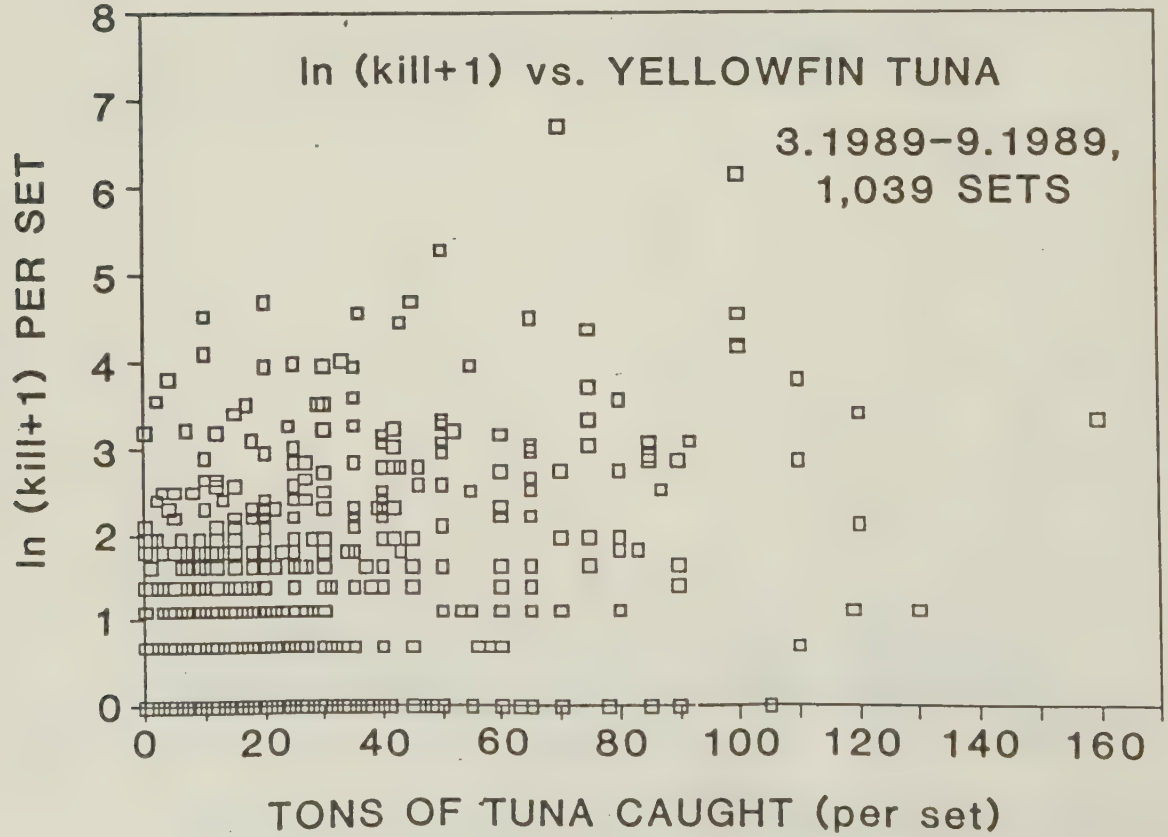


Figure 3. Plots of ln(Kill+1) vs. tons of tuna caught per set and dolphin capture per set

APPENDIX A

Data Base Structure For Data Base I (NMFS observer manual, 1986)

Number of data records: 1039

FIELD NAME	EXPLANATION
1) CRUISE	Cruise number
2) SET	Set number
3) DATE	Date of set
4) POSITION	The latitude in degrees (3 digits) and minutes (2 digits) North or South of equator, followed by a one digit, coded North = 1, South = 2. The longitude in degrees (3 digits) and minutes (2 digits) East or West of Greenwich, England, followed by one digit, coded East = 1, and West = 2
5) TIME-CHASE-BEGAN	The time when the first speedboat(s) was lowered onto the water
6) TIME-NET-LET-GO	The local time at which the net skiff hits the water
7) EXPL-CLASSC-USED	The coded answer to the question, "Were any Class III [C] explosives, aka seal bombs, used within 100 yards of the porpoise [dolphins] in this school at any time during the chase or set?" Yes = 1, No = 2, Blank if unobservable or undetermined
8) TIME-RINGS-UP	The local time at which the purse rings were brought above the surface of the water
9) OBS-BST-EST-CAP	The observer's best estimate of the total number of marine mammals in the net when the rings came up
10) OBS-SPT-CAP	Observer estimate of the % spotters

		in the net when the rings came up
11)	OBS-EASTERN-CAP	Observer estimate of the % eastern spinners in the net when the rings came up
12)	OBS-WB-CAP	Observer estimate of the % whitebelly spinners in the net when the rings came up
13)	OBS-SPN2-CAP	Observer estimate of the % other or unidentified spinners in the net when the rings came up
14)	OBS-OTHR1-CAP	Observer estimate of the % of other species (1) in the net when the rings came up
15)	OBS-OTHR2-CAP	Observer estimate of the % of other species (2) in the net when the rings came up
16)	OBS-SPT-CD-CAP	The two-digit number code assigned to identify the spotter stock
17)	OBS-SPN2-CD-CAP	The two-digit code number assigned to identify other spinners or unidentified spinner stocks
18)	OBS-OTHR1-CD-CAP	The two-digit code number assigned to identify the species indicated as other SP. 1
19)	OBS-OTHR2-CD-CAP	The two-digit code number assigned to identify the species indicated as other SP. 2
20)	TIME-START-BD	The local time at which the backdown procedure is initiated, i.e., the first time at which the engines are shifted into reverse after the net is tied down
21)	TIME-END-BD	The local time the backdown procedure was finished, i.e., the time at which the engines are shifted out of reverse for the last time and the corks at the apex channel are up

22)	KNOWN-KILLED	The total number of the marine mammals that were positively determined to be dead in this set, i.e., the sum of checks on the tally sheet
23)	KNOWN-INJURED	The total number of marine mammals that were injured this set, 2 digits. Sum all the (+) and (?) on tally sheet plus all the injured prior to and during backdown
24)	TONS-YF	The best estimate of the total tons of yellowfin tuna loaded aboard during this set
25)	VESSEL-CODE	Vessel code
26)	OPERATOR-CODE	Special code for each skipper operating NMFS cruises
27)	OBS-BST-EST-SCHL	The observer's best estimate of the total number of marine mammals of all species in the aggregate for this set (from sighting record)
28)	OBS-SP1-PERCENT	The estimated percentage of the total aggregate represented by the species indicated as species (1) (from sighting record)
29)	OBS-SP1-CODE	The two-digit code number assigned to identify the species as species (1)
30)	OBS-SP2-PERCENT	The estimated percentage of the total aggregate represented by the species indicated as species (2) (from sighting record)
31)	OBS-SP2-CODE	The two-digit code number assigned to identify the species indicated as species (2)
32)	OBS-SP3-PERCENT	The estimated percentage of the total aggregate represented by the species indicated as species (3) (from sighting record)

33)	OBS-SP3-CODE	The two-digit code number assigned to identify the species indicated a species (3)
34)	OBS-SP4-PERCENT	The estimated percentage of the total aggregate represented by the species indicated as species (4) (from sighting record)
35)	OBS-SP4-CODE	The two-digit code number assigned to identify the species indicated as species (4)

APPENDIX B

Data Base Structure For Data Base II

Number of Data Records: 418

FIELD NAME	EXPLANATION
1) CRUISENUM	Cruise number.
2) SETNUMBER	Set number
3) TONSYF	The best estimate of the total tons of yellowfin tuna loaded (caught) aboard during this set
4) TOTKILL	The total number of marine mammals that were positively determined to be dead in this set, i.e., the sum of checks on the tally sheet
5) TOTINJ	The total number of marine mammals that were injured this set. Sum of all (+) and (?) on tally sheet, plus all injured prior to and during backdown
6) SBUSED	The coded answer to the question, "Were any Class III [C] explosives, aka seal bombs, used within 100 yards of the porpoise [dolphin] in this school at any time during this chase or set?" Yes = 1, No = 2, blank if unobservable or undetermined
8) NOCOMMENTS	No comments concerning seal-bomb use were found but the observer coded a yes response to seal-bomb use
9) SBUSEDCHAS	Were seal bombs used from any platform during the chase? This is the period of time prior to net let go
10) SBHELOCHAS	Were seal bombs used from a helicopter during chase?
11) SBSPDCHSE	Were seal bombs used by speedboats during chase?

12)	LETGORNGUP	Were seal bombs used during encirclement? The period of time between net let go and rings up
13)	SBHELOENCR	Were seal bombs used from helicopter during encirclement?
14)	SBSEINENCR	Were seal bombs used from the seiner during encirclement?
15)	SBSPDENCR	Were seal bombs used from speedboats during encirclement?
16)	SBSKIFENCR	Were seal bombs used from the skiff during encirclement?
17)	SBSEINBOW	Were seal bombs thrown from the seiner between the bow and skiff to prevent escape here?
18)	SBSPDTOW	Were seal bombs thrown from the seiner at the tow line to prevent escape of dolphins here?
19)	SBHELOTOW	Were seal bombs thrown from helicopter during encirclement at tow line?
20)	SBSPDTOW	Were seal bombs used by speedboats at tow line?
21)	RNGUPBKDST	Were seal bombs used after rings up prior to backdown start?
22)	BKDSTBKDFN	Were seal bombs used after backdown started until backdown finished?
23)	SBSEINBKD	Were seal bombs used from seiner during backdown?
24)	UPHILL	Were seal bombs used to prevent dolphins from swimming toward the seiner during backdown?
25)	DRIVEOUT	Were seal bombs used during backdown to drive dolphins down the backdown channel and out of the net?
26)	SBANYBTBKD	Were seal bombs used by any boat during backdown?

27)	SBSPDAPEX	Were seal bombs used by speedboat at apex to drive dolphins out of the net?
28)	DIRECTINJ	Did seal bombs cause any direct injury to dolphins?
29)	ANYFOREIGN	Were any bombs of foreign manufacture used?
30)	SBINCLUSTR	Were seal bombs used in a cluster?
31)	SBUSEDNUM	An indication of the number of seal bombs used during this set?
32)	MEMO	A description by the observer of the use of seal bombs for this particular set?